USDA FOREST SERVICE
GENERAL TECHNICAL REPORT NC-44

Thirty Years of Soil and Water Research by the Forest Service in Wisconsin's Driftless Area

A History and Annotated Bibliography

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Manuscript approved for publication October 6, 1975

1978

THIRTY YEARS OF SOIL AND WATER RESEARCH BY THE FOREST SERVICE IN WISCONSIN'S DRIFTLESS AREA—A HISTORY AND ANNOTATED BIBLIOGRAPHY

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Research on the causes and prevention of floods and erosion in the upper Mississippi Valley's unglaciated region (''Driftless Area'') was begun by the North Central (then Lake States) Forest Experiment Station in the late 1920's. This earlier program ended with the outbreak of World War II. A second program was begun in 1958. Now, 17 years later, we have finally answered the questions that were first asked nearly 50 years ago.

This history and bibliography lists and annotates the papers published during both programs and summarizes the content of unpublished papers in somewhat more detail. The papers are listed chronologically within subject matter categories. Some earlier work not published at the time was published as part of the second program that began in 1958. To retain the historical sequence in these cases, I based the chronological order on the *time of field work rather than on the time of publication.* Thus some authors and dates from the later program are included with the lists from the early program.

EARLY WORK BY BATES (1928-31)

The early work began with the appointment of Carlos G. Bates to the fledgling staff of the Lake States Forest Experiment Station at St. Paul, Minnesota, in 1927. Before coming to the Lake States Station Bates had been in charge of Forest Service research in the Rocky Mountains, including the now famous Wagon Wheel Gap streamflow experiment in Colorado, the first controlled watershed experiment on the effect of forests on streamflow in the United States.

With 20 years of ''forest influences'' research already behind him when he joined the Station, Bates was one of a small handful of men who pioneered the new field of watershed management. These were the times of the dust bowl, of soil erosion on a massive scale, and the Nation was just beginning to take notice.

Mississippi River floods and mud, and the wholesale destruction of farms by river terrace erosion in Wisconsin's Driftless Area (fig. 1), served to focus Bates' attention on erosion sources and causes in this region. In 1929 he began a special study of erosion in southwestern Wisconsin and southeastern Minnesota. This work included stream sediment sampling, measuring runoff and erosion from different land uses (by means of ''erosion traps'') and, in cooperation with the Agricultural Experiment Station of the University of Wisconsin, the study of gully erosion and control methods. Some of the results of this work can be found in the publications listed at the end of the section.

Figure 1.—*River terrace gully with "soil-saving dam", Buffalo County, Wisconsin, November 1931.*

This was also the time when flood *prevention* by better land management and other upstream measures was gaining ground as an alternative to the traditional engineer's concept of flood *control* by ever bigger and better engineering works. Bates was one of the leading protagonists in the controversy, as evident in this passage from reference (2):

"Since man became conservation-minded, the accepted method for river control has been to go to the sources, to correct watershed conditions as far as possible, and to erect check dams, straighten and rip-rap eroding channels, and otherwise improve the thousands of small feeder streams. Apparently such an undertaking is wholly beneath the dignity of the great modern engineers whose slogan is, 'Give me millions or give me death'."

Unchecked erosion was so widespread in the Driftless Area then that Bates felt that public acquisition of land was a necessity. Again from reference (2):

"...it is hardly reasonable to suppose that in a rich dairying region like southwestern Wisconsin, for example, land needed for fields or pastures will be devoted to the growing of trees, except through public acquisition of the land. That the public has a sufficient stake to justify this acquisition in critical areas, I think there can be no doubt."

Bates' assessment of the severity of the problem was based partly on his study of sediment movement in the area. The results were published in (1), pages 5-7, and in (3), pages 47-50.

Although most of the emphasis during these years was on river terrace gullies and stream sediment movement, Bates knew of the forest land gullies and was aware that they were caused by runoff from the "tableland" above. He mentioned this briefly in (1) and in the photo caption on page 2 of (3):

"This deposit of limestone fragments at the lower level is the result of cultivation on the table and above the present narrow belt of trees. Here is the beginning of a community problem."

Publications

(1) Bates, C. G. 1931. Chaining the father of waters. Am. For. 36(2):67-70, 106, 127.

Challenges a program that would spend millions for flood control but nothing for flood prevention. Describes results of stream sediment sampling in Driftless Area, and effect of land use: most silt comes from cultivated fields; forests yield practically no runoff, and even less silt, "except as streams from tableland fields cut gullies through them". Describes silt and bedload movement in streams, and the need for improved upstream practices.

(2) Bates, C. G. 1933. Soil erosion in the Mississippi Valley. J. For. 31:88-96.

Paper presented at the 13th annual convention of the Mississippi Valley Association at St. Louis, Missouri.

Discusses in general terms the role of vegetation and terraces in runoff and erosion control, how gullies grow, and the relation of soil erosion to stream siltation. Recommends a joint effort between land owners and governments, including public acquisition of land, to control erosion and floods. Discussion of gullies, soil-saving dams, and mechanical means of checking erosion alludes to conditions in the Driftless Area.

(3) Bates, C. G., and O.R. Zeasman. 1930. Soil erosion—a local and national problem. Wisconsin Agric. Exp. Stn. Res. Bull. 99, 100 p.

Discusses the natural balance between vegetation, soil, and erosional processes, with examples from southwestern Wisconsin. Describes the Driftless Area terrain and erosion problems, and gives data from runoff and erosion traps and stream silt sampling. Maximum runoff for different covers were, in percent: forest, 2.8; natural pasture, 7.2; hay, 17.7; cropland, 25.6; seeded pasture, 26.7. Describes recommended erosion control practices such as strip-cropping, terraces, and soil-saving dams for gully control.

(4) U.S. Department of Agriculutre, Forest Service. 1931. The growth of a gully. U.S. Dep. Agric. For. Serv., Tech. Note 49, 1 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Describes the gully process in the Driftless Area. One large gully in Wisconsin advanced at a rate of 500 feet per year between 1923 and 1929. At the same time the many branches developed nearly 1,000 feet of smaller gullies. Maximum depth was 50 feet, and about 400,000 cubic yards of material washed away, destroying 25 acres of land.

THE EROSION EXPERIMENT STATION YEARS (1932-41)

In 1931, the U.S. Department of Agriculture in cooperation with the Wisconsin College of Agriculture established the Upper Mississippi Valley Erosion Experiment Station ("Erosion" was later changed to "Conservation") on 160 acres of ridgeland near LaCrosse. Though primarily for cropland erosion research by the Soil Conservation Service (later to become "Agricultural Research Service") it was also a "branch station" for the Lake States Forest Experiment Station, first with Joseph H. Stoeckeler, then with Harold F. Scholz in charge of on-the-ground operations.

Unpublished Catchment Studies

The main activities centered around three small catchments in different land uses and a series of 10 large lysimeters. Runoff and soil loss along with other measurements and observations were monitored on both for a period of years. Other studies were carried on, both on and off Station land.

Sholz, Harold F. 1937. Erosion: Its relationship to woodlot managment and the use of critical slopes for pastures and tilled crops. Part I and Part II.

Neu, Robert G. 1940. Erosion: Its relationship to woodlot managment and the use of critical slopes for pastures and tilled crops. Part III.

Three small catchments were put under observation in 1933, and runoff and soil loss were continuously monitored through 1941 (fig. 2). All three sloped to the north and had similar soils. They were disignated A, B, and G. A (2.7 acres) was grazed forest, B (11.5 acres), ungrazed forest, and G (5.8 acres), grazed open. ("G" was converted from second-growth forest in 1932 by clearcutting and burning and by "closely supervised grazing". This produced a heavy bluegrass sod.) The most complete published summary of the results is given in (8).

Figure 2.—*Parshall flume with instrument shelter and silt collecting box, Watershed "B", Upper Mississippi Valley Soil Erosion Station, 1936.*

Snow and frost depths were measured on all three catchments for 3 years and soil temperature (measured 42 inches below ground by thermometers suspended inside galvanized pipes), on the grazed open and ungrazed forest catchments for 4 years. The results are shown in tables 1 and 2. Neu made these comments:

Table 1.—*Maximum and minimum mean frost depth on grazed and ungrazed catchments, 1937-1939*

(In inches)

Year	Maximum[1]			Maximum mean[2]		
	Ungrazed: Grazed			Ungrazed: Grazed		
	forest	Forest	Open	forest	Forest	Open
1937	10	14	22	4	8	10
1938	15	22	21	8	14	17
1939	7	18	26	2	7	13
Average	11	18	23	5	10	13

[1]Greatest individual depth measured.
[2]Greatest mean depth of 10 sample points.

Table 2.—*Maximum summer and minimum winter temperatures at 42 inches depth in grazed open and ungrazed forest catchments*

(In F)

Year	Summer		Winter	
	Forest	Open	Forest	Open
1935-1936	58.0	62.5	37.0	36.0
1936-1937	59.0	64.0	36.5	35.5
1937-1938	59.0	65.0	36.5	33.5
1938-1939	58.0	62.0	37.0	36.5
Average	58.5	63.4	36.8	35.4

"The frozen soil in the ungrazed woodlot is loose and crumbly while it is hard and compacted in the pasture areas.

"On the basis of existing records it can be stated that very little runoff occurs from pasture and woodlot areas on north-facing slopes during the spring breakup unless the thawing weather is accompanied by precipitation in the form of rain."

The forage value of forest versus open pasture was also studied. Woodland grazing was universally practiced, and the researchers sought information that could be used to discourage the practice on economic grounds. Much effort went into determining dollar values from the costs of clearing, fencing, and other practices, all of which would be meaningless today. The more useful value of total cow-days per acre per year was also computed. The 7-year means were: forest pasture, 62; open pasture, 128. In terms of carrying capacity, 1 acre of open pasture was worth 2 of forest pasture.

Publications-catchment

(5) Bates, C. G. 1936. The forest influence on streamflow under divergent conditions. J. For. 34:957-969.

Compares runoff under forest conditions in the Driftless Area of Wisconsin with that from mountain watersheds in Colorado (the famous Wagon Wheel Gap Study). Forest cover prevents surface runoff in both places. Discusses results from experimental catchments at LaCrosse. Analyzes the effect of land use on the flooding of Gilmore Creek, a small Driftless Area watershed in Minnesota.

(6) Bates, C. G. 1937. Controlling mad waters. Am. For. 43(6):278-281, 300, 321-322.

Discusses the Ohio River floods of January-February 1937, and the probable effects of upstream and downstream programs on future floods. Quotes data from catchment study at La-Crosse: the ungrazed forested catchment produced only 0.3 inches of runoff from 90 inches of rain over a 3-year period, including 0.03 inches from 6 inches of rain in a 6-day period.

(7) Bates, C. G. 1938. Reforestation and flood control. J. For. 36:1073-1079.

(Published version of a talk presented at a joint meeting of the Woodlands Section of the Canadian Pulp and Paper Association, the Canadian Society of Forest Engineers, the Association of Forest Engineers of the Province of Quebec, and the Society of American Foresters held in connection with the One Hundred Second Meeting of the American Association for the Advancement of Science, Quebec, Canada, June 27-30, 1938.)

Deals with the flood control controversy—upstream vs. downstream control and what happens to infiltrated water, based on data from The Upper Mississippi Valley Erosion Experiment Station at La Crosse. Gives an illustration from the Root River, in Minnesota's Driftless Area.

(8) Hays, O.E., A. G. McCall, and F. G. Bell. 1949. Investigations in erosion control and the reclamation of eroded land at The Upper Mississippi Valley Conservation Experiment Station near LaCrosse, Wisconsin, 1933-1943. U.S. Dep. Agric., Tech. Bull. 973, 87 p.

Summarizes 10 years of research by the Soil Conservation Service on developing practices to control runoff and erosion on agricultural land in the Driftless Area. Includes the results from a study by the Lake States Forest Experiment Station of runoff from three small catchments for the period 1935-1941. Annual runoff (in percent of rainfall) was 1.16 for grazed forest and 0.35 for open land pasture. Soil losses (in tons per acre) were 0.14 for grazed forest and 0.05 for open land pasture. Comparable values for strip-cropped land were 7.32 percent and 2.66 tons. The amounts from ungrazed forest were insignificant.

(9) Scholz, H. F. 1938. The grazed wood lot—potential flood hazard and low-grade pasture. U.S. Dep. Agric. For. Serv., Tech. Note 142, 2 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Grazed woods yield high runoff, and make poor pasture. During a period of severe floods, runoff from ungrazed woods was only 1/47 of that from pastured woods. Most of the year's water loss occurs during a few heavy rains. The data were from the experimental catchments at La Crosse.

(10) Scholz, H. F. 1937 and 1938. Forest cover keeps frost line at shallow depth. U.S. Dep. Agric. For. Serv., Tech. Note 130. Lake States For. Exp. Stn., St. Paul, Minnesota; and J. For. 36:78-79,

Frost in an open pasture penetrated to 10 inches, compared with 4 inches in an ungrazed woodlot. Frost in the pasture thawed from the top, but in the woodlot it thawed from the bottom. Frost disappeared from the woods two days earlier than from the pasture.

(11) Scholz, Harold F. 1951. The case against cows: 73 percent of Wisconsin farm woodlands subject to destructive pasturing. Tree Tips, p. 3-4; and Wisconsin Conserv. Bull. 16(12):3-5.

Gives some data from lysimeter and catchment studies at the La Crosse station from 1935 to 1938 to show how grazing can cause runoff and erosion.

Lysimeter Studies

The lysimeters (10 in all) were 20 feet long, 10 feet wide, and 4 feet deep, and were filled with undisturbed blocks of Fayette silt loam, a loess, plus an 8-inch layer of topsoil (fig. 3). They were operated from 1934 to 1942.

After a test period of about a year, treatments were established, and surface runoff, percolation, and soil loss were measured for 6 years. The treatments in six lysimeters were: hardwood seedlings with leaf mulch (two lysimeters); hardwood seedlings without leaf mulch; Scotch

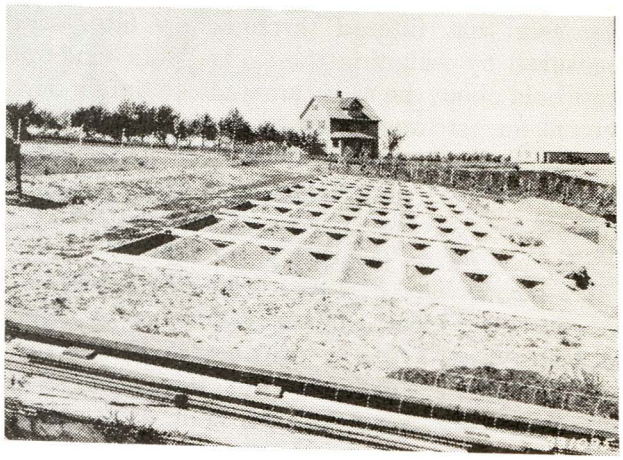

Figure 3.—*Forest Service lysimeters during test period, Soil Erosion Station, 1934.*

pine seedlings with needle mulch; grass, and annual grain. The four other lysimeters had faulty percolation records because of broken pipes that went undetected at the time.

Few results were published at the time, partly because of some "impossible" results that were caused by the broken pipes. Bates was writing up the experiment when he died in July 1949, and the lysimeters were destroyed soon afterwards. I wrote the final report in 1963 (15).

Several supplementary studies were conducted in conjunction with the lysimeters, one of which was reported by Curtis in 1960 (13).

Publications-Lysimeters

(12) Bates, C. G. 1939. Symposium on "Forest Influence" studies and methodology. Chron. Bot. 5(2/3):184-188.

A writeup of a meeting of Forest Service watershed management (then called "forest influences") research workers, held at the San Dimas Experimental Forest, near Glendora, California, February 12-27, 1939. Gives some results from a La Crosse lysimeter study.

(13) Curtis, Willie R. 1960. Moisture storage by leaf litter. U.S. Dep. Agric. For. Serv., Tech. Note 577, 2 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Galvanized tanks were placed under boxes that contained 2 to 3 inches of hardwood or pine litter. The rain that filtered through the litter was measured by weighing the tanks. Both kinds of litter held about the same amount of rainfall: 34.2 percent for hardwoods; 33.2 percent for pine. The amount retained varied from 93.7 percent for small rains to 11 percent for rains greater than 1 inch.

(14) Sartz, Richard S. 1963. Water yield and soil loss from soil-block lysimeters planted to small trees and other crops, southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Pap. LS-6, 23 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Surface runoff, percolation, and soil loss from lysimeters with different cover were measured for 6 years. Mulched tree seedlings and grass yielded little runoff and soil during the growing season, while unmulched seedlings and grain yielded large amounts. Differences by cover type were less distinct in the dormant season. Most of the percolation occurred during the dormant season. Annual variation was high in both seasons.

(15) Sartz, Richard S. 1964. Duration of percolation from a loess soil. U.S. Dep. Agric. For. Serv., Res. Note LS-40, 2 p. Lake States For. Exp. Stn. St. Paul, Minnesota.

Percolation from 4-foot deep lysimeters filled with loess soil was studied in southwestern Wisconsin. After complete soil moisture recharge, water percolated continuously for as long as 20 days without additional rainfall.

(16) Sartz, Richard S. 1965. Effect of forest litter on growth of hardwood seedlings. U.S. Dep. Agric. For. Serv., Res. Note LS-59, 2 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Red and white oak and black walnut seedlings grew much faster on lysimeters that had a covering of leaf litter than on a lysimeter without litter. The third year after treatment the mulched black walnut, red oak, and white oak averaged 55 percent, 51 percent, and 40 percent taller, respectively. The faster growth probably resulted from more available moisture.

(17) Scholz, Harold F., and J. H. Stoeckeler. 1940. A lysimeter installation for studying forest influence problems. J. For. 38:256-260.

Describes construction of 10- by 20-foot lysimeters filled with loess soil blocks. The lysimeters were planted to small trees and other crops to study the effect of cover on runoff, percolation, and erosion.

(18) U.S. Department of Agriculture. 1937. Forest litter and gravelly soils—effective conservers of water. U.S. Dep. Agric. For. Serv., Tech. Note 124, 1 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

A lysimeter study showed that both forest litter and gravel mulch produced little surface runoff, and that during the summer, forest vegetation used most of the precipitation that fell. The data were from 1 year.

Unpublished Farm Woods Erosion Study

Scholz, Harold F. 1935-1936. Farm woods erosion study. (In Part II of "Erosion: Its relationship to woodlot management and the use of critical slopes for pastures and tilled crops")

A "Farmwoods-Erosion Study" was carried out in 1935-1936 under the direction of Harold F. Scholz in cooperation with the Forest Survey section. Its objective was to determine the *economic* value of the farm woods of the area to supplement the information on their *protective* value being determined from the Erosion Station studies.

The study consisted of an intensive survey of 3½ townships (3 in Wisconsin, ½ in Minnesota). Besides taking the normal forest survey data, the surveyors mapped open land uses, woodland grazing, and erosion features. The results were given only in unpublished documents and in the survey maps, one of which is shown in figure 4.

Although Bates had earlier pointed to ridgeland runoff as the cause of forest land gullies, their ubiquity along with extensive abuse of the forest through high-grading and uncontrolled grazing led some to believe that the gullies were caused by runoff from the forest. The survey reports shed new light on the issue:

"This study has covered to date 46,000 acres of severely eroded land. Every gully observed began at the concentration point of water running off of cultivated land, or a heavily grazed or poorly stocked woodlot.

"Frequently the head of a gully was found on the upper edge of a good woodlot, but there was evidence in each case that the concentration of water came from cultivated land on a field above.

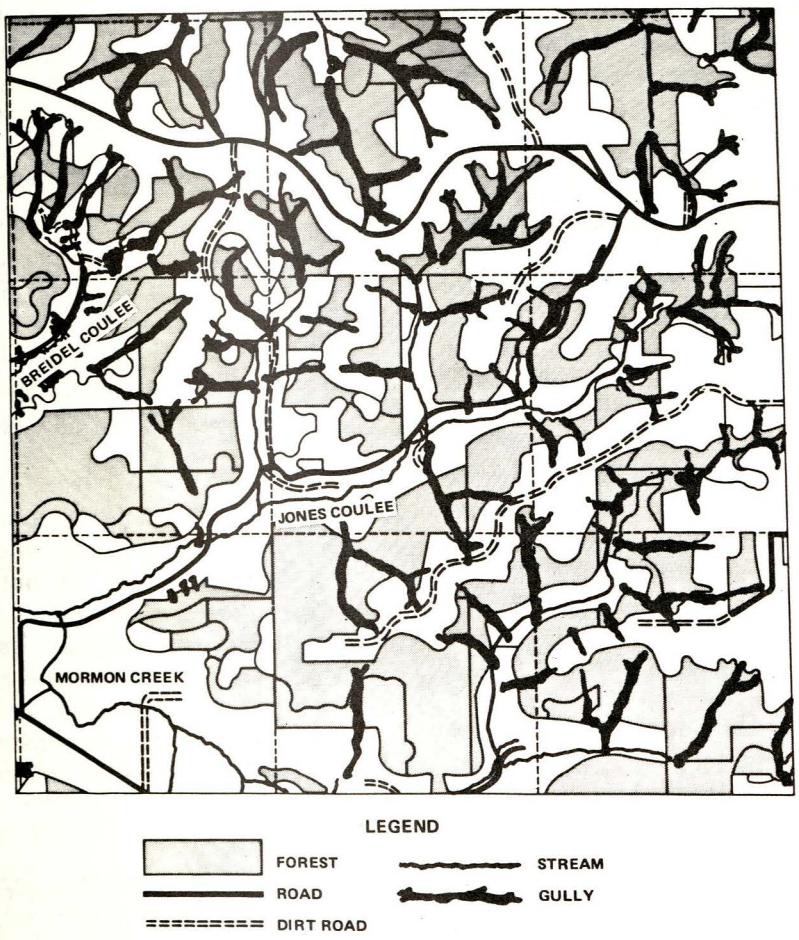

Figure 4.—*Land use and gully survey of sample township in LaCrosse County, Wisconsin, 1935.*

"...in 80 square miles that we have covered to date on this survey we have not found a single instance of erosion through forest except where it has been caused by open fields on the ridgetop."

Flood Control Surveys

In the Flood Control Act of June 22, 1936, the United States Congress officially recognized that watershed improvement measures should become an integral part of flood control planning. The act authorized the Department of Agriculture to conduct "flood control surveys"—field studies to determine to what extent floods could be prevented or reduced on individual watersheds through land use change and small engineering structures. The surveys were conducted jointly by the Soil Conservation and Forest Services.

Flood control surveys on the Kickapoo River in Wisconsin, and on the Whitewater River in Minnesota, both in the Driftless Area, were begun in 1938; and most of Bates' and Scholz's efforts were devoted to these surveys for the next few years.

THE COULEE EXPERIMENTAL FOREST AND FOREST WATERSHED LABORATORY YEARS (1958-1975)

After a 20-year lapse, watershed research was begun again in the Driftless Area when Congress appropriated money in 1958 for a Research Center at La Crosse. I was the first and only Project Leader. Creation of the center had been recommended by the Wisconsin Forestry Advisory Committee, and under a cooperative agreement with the (then) Wisconsin Conservation Department, the State agreed to provide a suitable outdoor laboratory for the research. The outgrowth was the Coulee Experimental Forest, a 2,900-acre area in La Crosse County typical of the land forms, soils, and land use in the unglaciated area. The forest was formally dedicated in June 1960.

The research unit was originally quartered in the La Crosse Federal Building, but in 1967 it moved to its own newly constructed laboratory building on land leased from the city (fig. 5).

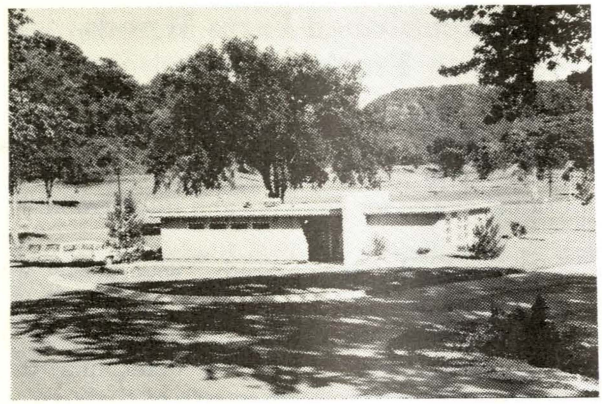

Figure 5.—*Forest Watershed Laboratory, La-Crosse, project headquarters from 1967-1975.*

The primary mission of the new center was to study the effect of land use and steep land management on floods, soil erosion, and stream sedimentation—essentially a continuation of the earlier work but on a broader scale. A secondary mission during the early years of the project was to study the adaptability of various tree species and classes of planting stock to different sites. The information was sought to guide land owners in their tree-planting programs.

With its mission all but completed, the project was terminated and the laboratory building was turned over to the City of La Crosse at the end of 1975. The Department of Natural Resources continues to administer the state-owned Coulee Experimental Forest as a research area.

During its last few years, the La Crosse Field Unit began to work on land disposal of sewage effluent. This was an outlier of the primary effluent disposal project at East Lansing, Michigan. Field work on this mission was done at Fort McCoy under a cooperative agreement with the Department of the Army. The work was disbanded and the agreement terminated with the closing of the Forest Watershed Laboratory.

The publications that came from this era are given in the lists below, subdivided according to the primary subject matter. An easy-to-read summary of land managment recommendations is found in (32).

Unpublished—Soil Freezing

Harris, Alfred Ray. 1971. Effect of deciduous, coniferous, and abandoned field cover on the hydrologic properties and frost morphology of frozen soil. Ph.D. thesis. Univ. Minnesota, St. Paul, Minnesota.

During the 1969-70 freezing season the hydrologic properties and morphology of frozen Fayette silt loam soil under contiguous areas of natural deciduous forest, 25-year-old coniferous plantation, and 6-year-old abandoned field vegetation were studied.

The deciduous forest had the least frost, the conifer plantation, the most. All plots had concrete frost. Infiltration rates in the deciduous forest and abandoned field did not decrease significantly until late winter when snowmelt infiltrated and froze, blocking drainage pores. Rates in the conifer plantation were very low because of an ice layer that formed when snowmelt dripped from the canopy. Infiltration rate was not significantly correlated with bulk density, water content, air pore volume, or total pore volume, partly because of the large macro pore volume in the soil.

Bulk density reductions were greatest in the deciduous forest plots, and were greater for the surface soil layer than for the subsurface soil layer. Both bulk density and air pore volume were inversely correlated with water content.

Publications—Soil And Water

Land use effects on soil properties, runoff, and erosion:

(19) Curtis, Willie R. 1966. Forest zone helps minimize flooding in the Driftless Area. J. Soil Water Conserv. 21(3):101-102.

Forested slopes absorb rainfall runoff from upland fields, reducing water movement, soil erosion, and downstream flooding in southeastern Minnesota and southwestern Wisconsin.

(20) Curtis, Willie R. 1967. Simple practices along forest edge reduce upland runoff. J. Soil Water Conserv. 22(1):25-26.

The portion of upland runoff that reaches valley bottoms can be reduced by diversions and simple land treatments, such as logs along the contour in natural forest and detention ponds in series installed along the field-forest border.

(21) Knighton, M. Dean. 1970. Forest floor characteristics in southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Note NC-102, 2 p.m North Cent. For. Exp. Stn., St. Paul, Minnesota.

Percent slope, aspect, topographic position, and crown closure did not influence forest floor depth. However, a decrease in forest floor depth and an increase in soil compaction were found on currently grazed slopes. Cessation of grazing resulted in rapid recovery.

(22) Knighton, M. Dean. 1977. Soil changes after hay meadow abandonment in southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Pap. NC-146, 6 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Soil ameliorating processes that accompany agricultural abandonment of alfalfa hay meadows were studied for 3 years. Average bulk density decreased from 1.28 to 1.10 in 2 years and then stabilized. As expected, total porosity increased; most of the change occured in the large pore fraction. Organic carbon increased from 1.60 to 2.20 percent during the 3 years. Infiltration rate increased 100 percent over that of adjacent active hay meadows. Earthworm activity was considered to be the primary cause of the changes.

(23) Knighton, M. Dean. 1977. Hydrologic response and nutrient concentrations following spring burns in an oak-hickory forest. Soil Sci. Soc. Am. J. 41:627-632.

Three annual spring burns in southwestern Wisconsin did not increase overland flow or soil loss on sloping (25 to 50 percent) plots. However, no particularly severe storms occurred during the study. The protective characteristics of the ground cover were not altered, and shrubs sprouted vigorously. Bulk density, total pore volume, organic carbon content, and intrinsic permeability

of the mineral soil were unaffected, but mobility of nitrate-nitrite nitrogen and phosphate increased with the number of burns. Calcium and magnesium mobility was increased but potassium and sodium mobility was not. Nutrient loss by leaching was less than the input from precipitation.

(24) Sartz, Richard S. 1959. Forests and water: A tale of two watersheds. Wisconsin Acad. Rev. 6:55-58.

How forests minimize floods and erosion is told by describing what happens when both a forested and a bare watershed are hit by a heavy rain.

(25) Sartz, Richard S. 1960. Forests and erosion in the Driftless Area. Wisconsin Conserv. Bull. 25(3):21-24.

Explains how geologic erosion shaped the land forms of the Driftless Area and how man has triggered a new cycle of erosion through overdevelopment of the land for agriculture. A study of wooded watersheds showed no accelerated erosion.

(26) Sartz, Richard S. 1961. The forest-land gully in the Driftless Area—natural or man-caused? U.S. Dep. Agric. For. Serv., Tech. Note 612, 2 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

To test the theory that the forest-land gully—a common feature of the Driftless Area—has resulted from ridgetop farming, a survey of 40 completely forested drainages was made to check for gullies or other signs of surface flow. Not a single gully or eroded channel was found. Other evidence also strongly suggests that gully erosion was not a feature of the natural landscape.

(27) Sartz, Richard S. 1961. Comparison of bulk density of soil in abandoned land and forest land. U.S. Dep. Agric. For. Serv., Tech. Note 601, 2 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Soil core samples taken in the same soil type (Dubuque silt loam) under two different land uses showed the effects of land clearing and cultivation on bulk density of the soil. In the natural soil profile under an oak-hickory stand, bulk density in the upper 3 inches was 0.70. In the open land profile it was 1.08. Bulk density in the 3- to 6-inch layer was slightly higher in the forest than in the open, but from 6 to 24 inches there was little difference.

(28) Sartz, Richard S. 1965. Forestry research to benefit trout? Wisconsin Conserv. Bull. 30(2):20-21.

This popular-style article explains how land use, through its effect on infiltration and soil freezing, can influence flood runoff and the base flow of streams, both key factors in trout stream management. By better defining the effects of different tree species and cutting patterns, forestry research can benefit trout.

(29) Sartz, Richard S. 1969. Effect of watershed cover on overland flow from a major storm in southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Note NC-82, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Both total and peak flows from a 3-hour, 4-inch rain were strongly affected by land cover. Peak flows ranged from 2.42 inches per hour for alfalfa meadow to 0.010 inches per hour for undisturbed forest. The timing of flow on open land and forested catchments was surprisingly similar.

(30) Sartz, Richard S. 1970. Effect of land use on the hydrology of small watersheds in southwestern Wisconsin. Int. Assoc. Sci. Hydrol., Symposium on the results of research on representative and experimental basins. IASH-Unesco 96:286-295. (Wellington, New Zealand, Dec. 1970).

Forest watersheds produced flow only after heavy rains, and the amounts of flow and peak rates were low compared with those from openland watersheds. Peak flow rates from a major storm ranged from 64 millimeters per hour for tilled land to no flow for undisturbed forest. Peak rates from tilled land averaged 2.5 times those from meadow, and peak rates from meadow 1.4 times those from an abandoned field. Sediment discharge was low for forest, abandoned field, and meadow, but high for tilled land and heavily grazed pasture.

(31) Sartz, Richard S. 1971. Storm flow from dual-use watersheds in southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Pap. NC-69, 7 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Compares storm flow from upland fields with outflow at the bottom of wooded slopes below. In general, larger upland flows produced larger lower station flows. Lower station flow as a percentage of upland runoff for large storms ranged from 56 to 94.

(32) Sartz, Richard S. 1975. Controlling runoff in the Driftless Area. J. Soil Water Conserv. 30:92-93.

Tilled cropland is the major source of floods and stream sediment in the unglaciated region; thus, reducing the cropland area in a watershed is an effective flood prevention measure. Hayland and pastureland produce much less runoff than tilled land, and little sediment. Simply taking land out of active cultivation greatly reduces the amount of water that flows from sloping fields. Runoff from forest land is minimal, regardless of its condition.

(33) Sartz, Richard S. 1976. Sediment yield from steep lands in the Driftless Area. *In* third Federal interagency sedimentation Conf. Proc., Denver, Colorado, March 22-26, 1976.

Substantial amounts of sediment were discharged only from cultivated or heavily grazed catchments. The greatest amounts—sometimes exceeding 200,000 parts per million—came from tilled cropland in early stages of crop development. Ungrazed forest and prairie yield no significant amounts of runoff or sediment, regardless of slope steepness, unless they intercept water from overlying fields. However, field runoff can carve huge gullies on forested slopes that lie below cultivated uplands. Thus, the forested slopes of the area have been a major sediment source from gully erosion since the time of settlement.

(34) Sartz, Richard S. 1976. Effect of plantation establishment on soil and soil water in southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Pap. NC-127, 8 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Changes in litter weight, soil bulk density, soil nitrogen and organic carbon contents, soil water depletion, and snowpack accumulation were evaluated over 14 years of plantation growth on three different sites. The species studied were white and red pines, white spruce, and European larch, along with unplanted controls.

(35) Sartz, Richard S. [In press.] Soil erosion in the Lake States Driftless Area—a historical perspective. Transactions, Wisconsin Academy of Sci., Arts, and Letters.

The history of both geologic and man-caused erosion in the upper Mississippi Valley's "Driftless Area" and man's sometimes futile control efforts are presented in this popular-style article, with eight illustrations.

(36) Sartz, Richard S., Willie R. Curtis, and David N. Tolsted. 1977. Hydrology of small watersheds in Wisconsin's Driftless Area. Water Resour. Res. 13(3):524-530.

Steep, unglaciated terrain, and a peculiar land use pattern give the Upper Mississippi Valley's unglaciated region a distinctive hydrology. Catchments smaller than 250 hectares normally have no perennial streams, but may have many springs that flow for short distances and then reenter the ground. Land use greatly influences the surface hydrology. Tilled cropland is the principal source of flood runoff and stream sediment. Runoff from forest land is minimal regardless of its slope or condition. The ground water picture is complex, with perched water bodies and dry pockets intermixed with water tables that rise and fall in rapid response to rainfall and snowmelt and in close synchronization with springflow. Snowmelt produces a distinctive diurnal pattern of both overland flow and ground water rise, sometimes in midwinter. Larger catchments responded to both rainfall and snowmelt much the same as smaller experimental catchments.

(37) Sartz, Richard S., and Alfred Ray Harris. 1972. Growth and hydrologic influence of European larch and red pine 10 years after planting. U.S. Dep. Agric. For. Serv., Res. Note NC-144, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Ten years after planting, European larch and red pine diameters averaged 11.2 and 9.6 cm, and heights, 9.7 and 5.1 m. Litter on the larch plots was twice as heavy as on the pine and unplanted control plots. The amount of water depleted by the two species was about the same, and it was about twice the amount depleted by a grass and weed cover.

(38) Sartz, Richard S., and David N. Tolsted. 1974. Larch litter removal has no significant effect on runoff. U.S. Dep. Agric. For. Serv., Res. Note NC-163, 2 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Runoff was measured on paired litter-removed, litter-left plots in an 11-year-old European larch plantation. On five of the six pairs of plots, the plot with the litter left intact yielded more runoff. However, the differences were neither statistically nor hydrologically significant.

(39) Sartz, Richard S., and David N. Tolsted. 1974. Effect of grazing on runoff from two small watersheds in southwestern Wisconsin. Water Resour. Res. 10:354-356.

Runoff behavior of two small open pasture catchments was similar when both were grazed, but by the third year after cessation of grazing on one, its runoff had dropped sharply. The ungrazed /grazed ratio for mean total flow had dropped from 1.17 to 0.10 and for mean peak flow from 0.82 to 0.03. After 3 years without grazing a heavy mat of bluegrass blanketed the ground, and soil bulk density was significantly lower.

(40) Stoeckeler, J.H. 1959. Trampling by livestock drastically reduces infiltration rate of soil in oak and pine woods in southwestern Wisconsin. U.S Dep. Agric. For. Serv., Tech. Note 556, 2 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Livestock trampling reduced infiltration by 93 percent as measured by 3-inch cylinders. (See also (41) and (44).

Soil freezing:

(41) Harris, Alfred R. 1972. Infiltration rate as affected by soil freezing under three cover types. Soil Sci. Soc. Am. Proc. 36:489-492.

Infiltration rates on abandoned land may be as high as on deciduous forest. Infiltration was affected mainly by the number and orientation of connected macropores and by the degree of blockage of the larger drainage channels with ice. Ice crust formation may be a problem caused by tight conifer canopies and can contribute to runoff.

(42) Sartz, Richard S. 1969.Soil water movement as affected by deep freezing. Soil Sci. Soc. Am. Proc. 33:333-337.

Changes in soil water content took place throughout much of the frost season, even with deep soil frost. Water may infiltrate and percolate through more than 60 cm of hard-frozen ground. However, frozen ground did impede percolation, causing a buildup of water in the frozen zone during spring melt.

(43) Sartz, Richard S. 1970. Natural freezing and thawing in a silt and a sand. Soil Sci. 109:319-323.

Although the two soils began to freeze at the same time, frost penetrated faster and deeper and thawed sooner in the sandy soil. During the spring thaw, frost persisted in the silt 3 weeks longer than in the sand. The sand began thawing at the surface 7 days before the silt, and it was completely thawed 15 days later.

(44) Sartz, Richard S. 1973. Effect of forest cover removed on depth of soil freezing and overland flow. Soil Sci. Soc. Am. Proc. 37:774-777.

Removing only the litter and removing all the vegetation from hardwood forest plots increased both soil freezing depth and overland flow. Removing only the woody vegetation decreased both. Frost depth means in a year of deep frost were 6 and 11 cm on the woody vegetation removed and undisturbed plots, and 19 and 35 cm on the all vegetation removed and litter-removed plots. Overland flow ranged from less than 1 cm on the woody vegetation-removed plots to more than 7 cm on the all vegetation- and litter-removed plots.

(45) Sartz, Richard S. 1973. Snow and frost depths on north and south slopes. U.S. Dep. Agric. For. Serv., Res. Note NC-157, 2 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Aspect affects soil frost depth by influencing the amount of solar radiation received at the ground or snow surface. Depending on the conditions, frost can be of equal depth on north and south slopes, deeper on north slopes, or deeper on south slopes. Data illustrate all three conditions. [See also (80).]

Springflow and ground water:

(46) Curtis, Willie R. 1963. Flow characteristics of two types of springs in southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Note LS-1, 2 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Springs on the Coulee Experimental Forest are found at two levels—approximately 900 and 1,000 feet above sea level. Flow from the 1,000-foot springs is practically constant the year round, while flow from the lower level springs varies by season, month, and day in relation to climatic variables. A hydrograph of daily discharge for 1961 for each level of spring is presented.

(47) Curtis, Willie R. 1966. Response of springflow to some climatic variables in southwestern Wisconsin. Water Resour. Res. 2:311-314.

Springflow responds to barometric pressure in southwestern Wisconsin, and it fluctuates much as does ground water in response to precipitation and soil moisture.

(48) Sartz, Richard S. 1967. Winter thaws can raise ground water levels in Driftless Area. U.S. Dep. Agric. For. Serv., Res. Note NC-35, 2 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Springflow and ground water levels both rose with winter thaws, even when the ground was frozen. A high soil water content suggests that water moved to the water table through a continuous column of soil water rather than as a wetting front.

(49) Stoeckeler, Joseph H., and Glenn J. Voskuil. 1959. Water temperature reduction in shortened spring channels of southwestern Wisconsin trout streams. Am. Fisheries Soc. Trans. 88:286-288.

Late afternoon summer water temperature at the mouth of a spring channel on a trout stream near La Crosse in southwestern Wisconsin were reduced by 10 degrees to 11 degrees F. by shortening the channel by 67 percent and routing the water through a willow-shaded location. [See also (36).]

Evapotranspiration:

(50) Sartz, Richard S. 1972. Anomalies and sampling variation in forest soil water measurement by the neutron method. Soil Sci. Soc. Am. Proc. 36:148-153.

Sampling errors were determined for neutron meter measurements of soil water content in a heterogeneous forest soil. Variance at individual 30-cm depths on uncut plots increased with depth at a high water content but was uniform at a low water content. Changes over a period of time were more variable than at a single point in time. Soil depth differences contributed substantially to the variance of total storage changes.

(51) Sartz, Richard S. 1972. Soil water depletion by a hardwood forest in southwestern Wisconsin. Soil Sci. Soc. Am. Proc. 36:961-964.

Water depletion by uncut forest began early in the growing season at all depths measured and continued at a nearly constant rate until leaf fall. Seasonal depletion in a 1.5 m soil mantle averaged 188 mm on uncut plots, 87 mm on clearcut plots, and 57 mm on plots without vegetation. The amount of depletion increased with mantle depth; thus cutting had a greater water-saving effect on deeper soils.

(52) Sartz, Richard S., and M. Dean Knighton. 1978. Soil water depletion after four years of forest regrowth in southwestern Wisconsin. U.S. Dep. Agric. For. Serv. Res. Note NC-230, 3 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

The effect of cutting on water depletion from a 150-cm soil mantle does not appear to have diminished by the 7th year after the trees were cut. Mean seasonal depletion was 41, 64, and 146 mm for all-vegetation-removed, woody-vegetation-removed, and uncut treatments, respectively. After 4 years of regrowth, the original bare and clearcut treatments depleted only 21 and 35 percent as much water as the uncut forest.

(53) Stoeckeler, J.H., and Willie R. Curtis. 1960. Soil moisture regime in southwestern Wisconsin as affected by aspect and forest type. J. For. 58:892-896.

Gives results of soil moisture on a transect across a valley, from ridge to ridge, showing markedly better moisture conditions on north- versus south-facing slopes. Tree growth in pine plantations was 3.5 times better than in oak on south-facing slopes. [See also (34) and (37).]

Climate:

(54) Sartz, Richard S. 1966. Rainfall distribution over dissected terrain in southwestern Wisconsin. Water Resour. Res. 2(4):803-809.

Dissected terrain of southwestern Wisconsin has only a small effect on annual point rainfall; the variance in rainfall within such an area probably results more from normal storm variation.

(55) Sartz, Richard S. 1967. Annual soil temperature wave at four depths in southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Note NC-32, 2 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

The annual soil temperature wave measured on a southeast slope in southwestern Wisconsin followed the air temperature wave at all depths.

(56) Sartz, Richard S. 1972. Effect of topography on microclimate in southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Pap. NC-74, 6 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Ridge and coulee terrain has little effect on point rainfall, but snowpack accumulation is affected by degree of slope and aspect. North slopes accumulate about 50 percent more snow. Soil water depletion is little affected by aspect. South slopes receive more insolation than north slopes, but temperature differences are slight and may result more from wind differences than from aspect. Air drainage has a significant effect on nighttime air temperatures in coulee bottoms.

(57) Stoeckeler, Joseph H. 1963. Springtime frost frequency near LaCrosse, Wisconsin, as affected by topographic position, and its relation to potential reforestation problems. J. For. 61:379-381.

Frosts of 30° F or less were eight times more abundant in a 2-year period in a cove at elevation of 920 feet above sea level than in a nearby ridgetop at 1,250 feet elevation.

Publications—Reforestation

(58) Knighton, M. Dean. 1970. Simazine may stunt young European larch. Tree Plant. Notes 21(2):17.

Fall spraying young European larch with Simazine reduced height growth by 14 percent and increased mortality 2 percent the year after spraying.

(59) Knighton, M. Dean. 1972. Effects of ground preparation on planted red pine in southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Note NC-134, 2 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

After 9 years, 3-0 red pines planted by machine and by hand in single plowed furrows had 37 percent more survival than trees hand planted in scalps. Planting method did not affect survival of 2-1 transplants. Height growth was 18 percent greater for machine and single-furrow planted trees than for hand planted trees. Bench terraces and double furrows gave intermediate values.

(60) Sartz, Richard S. 1965. Effect of forest litter on growth of hardwood seedlings. U.S. Dep. Agric. For. Serv., Res. Note LS-59, 2 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Red and white oak and black walnut seedlings grew much faster on lysimeters that had a covering of leaf litter than on a lysimeter without litter. The third year after treatment the mulched black walnut, red oak, and white oak averaged 55 percent, 51 percent, and 40 percent taller, respectively. The faster growth probably resulted from a greater supply of available moisture.

(61) Sartz, Richard S. 1968. Hail can seriously damage eastern white pine. J. For. 66:353.

Hail seriously damaged a seventh-year white pine plantation by riddling the bark on main stems and lateral branches. Red pine, white and Norway spruces, and European larch on the same site were not damaged.

(62) Sartz, Richard S. 1970. Mouse damage in young plantations in southwestern Wisconsin. J. For. 68:88-89.

Meadow voles caused serious losses in old-field plantings of Austrian and Scotch pine, Norway spruce, and European larch. White pine was not heavily attacked, and white spruce was passed up completely. No damage or other mouse signs were found on south aspect plantings.

(63) Stoeckeler, J.H. 1962. Planting research on the Coulee Forest. Wisconsin Conserv. Bull. 27(1):10-11.

Describes a new program of reforestation research started in spring 1961 on the Coulee Experimental Forest near La Crosse, Wisconsin, in cooperation with the Wisconsin Conservation Department. Planting trials the first year with 25,000 trees involved 11 species, 4 age classes, and 2 transpiration retardants planted on both cool and hot aspects of microsite.

(64) Stoeckeler, J.H. 1962. Angle-dozer used for tree planting. J Soil Water Conserv. 17:178-179.

A small angle-dozer was used with good economy in making 30.5 miles of level, narrow bench terraces at an average cost of $12.20 per mile, or $12.57 per acre for a calculated 8-foot spacing between rows. The study was made in hilly terrain in southwestern Wisconsin with slopes up to 32 percent. Advantages and limitations of the method are discussed.

(65) Stoeckeler, Joseph H. 1963. Ground preparation costs and first-year survival of planted red pine in southwestern Wisconsin. U.S. Dep. Agric. For. Serv., Res. Note LS-28, 4 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

A comparison is made in field survival and costs for 3-0 and 2-1 red pine planted in five different types of ground preparation; that is, bench terraces, single furrows, double furrow, Lowther machine, and scalps.

(66) Stoeckeler, Joseph H. 1963. Early survival of planted trees in southwestern Wisconsin, by species, age classes, and site factors. U.S. Dep. Agric. For. Serv., Res. Note LS-27, 4 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Survivals are given for first and second years for all species combined, and for the commonly planted 2-0, 3-0, and 2-1 red pine on 10 field reforestation plots of various aspects, soils, and topographic positions. Species and age-class recommendations are made for six classes of sites.

(67) Stoeckeler, J.H. 1964. Two-year results of direct-seeded black walnut in a cove on the Coulee Experimental Forest, LaCrosse, Wisconsin. Tree Plant. Notes 67:12-13.

A second-year stocking of 85 percent and a germination of 49 percent were achieved in directly field seeding three seeds per seed spot in conventional 12-inch-wide furrows.

(68) Stoeckeler, Joseph H. 1965. Spring frost damage in young forest plantings near LaCrosse, Wisconsin. J. For. 63:12-14, and Am. Christmas Tree Growers' J. 9(2):36, 38-40.

Observations of effects of spring freezing of May 22-23, 1963, on 13 tree species in second- and third-year plantations near La Crosse, Wisconsin, indicate the following sensitivity to frost injury: sensitive—Norway spruce, white spruce, European larch; slightly sensitive—Austrian pine; not sensitive—jack, ponderosa, red, Scotch, and white pines and eastern redcedar. Some variation was noted in frost damage by altitude.

(69) Stoeckeler, J. H. 1966. Hexadecanol applied to foliage improves early field survival of pine planting on a droughty site. J. For. 64:200-201.

Hexadecanol, a saturated, fatty alcohol, reduced the drought loss of 3-0 red pine planted on a steep, dry, windswept hillside in Wisconsin.

(70) Stoeckeler, J. H. 1966. Trees for the Coulee Region. Wisconsin Conserv. Bull. 31(1):14-16.

Pinpoints the species responding the best of 13 planted in Wisconsin's Coulee Region according to nursery-stockage class, ground preparation, aspect, soil condition, ground cover, and topographic position.

Publications—Research Instruments and Techniques

(71) Curtis, Willie R. 1960. An automatic trigger device for use on FW-1 water level recorders. J. For. 58:819-821.

Explains construction and operation of a time-saving trigger device used in conjunction with water-level recording on ephemeral streams. During no-flow periods the clock is kept from running by application of back pressure. When flow occurs, movement of float activates release mechanism and clock begins to run.

(72) Curtis, Willie R. 1961. An inexpensive water-level point gage. U.S. Dep. Agric. For. Serv., Tech. Note 613, 2 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Materials and methods of construction of an inexpensive water level point gage are described. The gage is for use in conjunction with streamflow recording stations. Three photographs show general view and specific details of construction.

(73) Curtis, Willie R. 1963. Device for automatically starting a recording rain gage when rainfall begins. U.S. Dep. Agric. For. Serv., Res. Note LS-3, 3 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

The device described allows a recording rain gage to operate only after rainfall begins. Only a few drops of water are necessary to trigger the mechanism. Construction detail is shown in three photos, and the needed materials are listed.

(74) Curtis, Willie R. 1963. Tool for editing analog-to-digital tapes. J. Soil Water Conserv. 17:254.

Describes details of construction and use of a tool that aids in the editing and computing of punched tape obtained with analog-to-digital recorders.

(75) Curtis, Willie R., and David N. Tolsted. 1967. Chart holder uses old typewriter parts. Agric. Eng. 48(3):154-155.

Describes how to make and use a chart holder that increases accuracy and reduces calculation time when computing runoff volumes by the Copley method. Most of the parts can be salvaged from an old typewriter.

(76) Hansen, Edward A., and Alfred Ray Harris. 1974. A ground water profile sampler. Water Resour. Res. 10(2):375.

A ground water profile sampler was developed for obtaining water samples at predetermined depths. This permits determining the gradients of contaminants in a ground water system.

(77) Hansen, Edward A., and Alfred Ray Harris. 1975. Validity of soil-water samples collected with porous ceramic cups. Soil Sci. Soc. Am. Proc. 39:528-536.

Laboratory and field tests were made to determine if porous ceramic cups collect representative samples of nitrate and phosphate from soil water. Sources of sample bias were sorption, leaching, diffusion, and screening of ions by the cup walls. Sample variability was strongly influenced by sampler intake rate, plugging, sampler depth, and type of vacuum system. The demonstrated variability and unknown bias make interpretation of sampler data difficult.

(78) Harris, Alfred Ray. 1970. Direct reading frost gage is reliable, inexpensive. U.S. Dep. Agric. For. Serv., Res. Note NC-89, 2 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

A tube-type gage is economical, easy to make, and is a reliable indicator of frost depth. Gage readings were within 5 cm of indicated true frost depth 95 percent of the time.

(79) Harris, Alfred Ray. 1975. Evaluation of several methods of applying sewage effluent to forested areas in the winter. Agron. Abstracts, 67th Annual Meeting Am. Soc. Agron., p. 166. (Knoxville, Tennessee, Aug. 24-30, 1975.)

Sewage effluent was applied by surface, subsurface, and sprinkler systems to a forested area for two winters at Fort McCoy, Wisconsin. Water distribution in the frozen soil was generally poor for all the systems. Wet spots were interspersed with dry spots in the frozen soil indicating that water did not distribute evenly but merely enriched areas close to conducting

channels. Although substantial effluent infiltrated the frozen soil with each method, the feasibility of wintertime irrigation in forested areas is still uncertain because of site disturbance and poor renovation of effluent.

(80) Harris, Alfred Ray, and Edward A. Hansen. 1975. A new ceramic cup soil-water sampler. Soil Sci. Soc. Am. Proc. 39:157-158.

A newly designed soil-water sampler utilizing a miniature porous ceramic cup is suitable for either collecting large samples or for micro techniques. It eliminates sample transfer in the field and contamination from water channeling along sampler, and can be enclosed to discourage vandalism. It also permits immediate preservation of the collected sample.

(81) Knighton, M. Dean. 1978. Estimating infiltration from soil properties for a loessal silt loam. U.S. Dep. Agric. For. Serv., Res. Note NC-233, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

An infiltration model for a loessal silt loam in southwestern Wisconsin was developed and tested. The model depends on soil physical properties for estimating infiltration. The properties showing the greatest significance were organic carbon content, total pore space, and moisture content. Bulk density and large pore space also proved to be significant. The model adequately predicted final infiltration rates but was weaker with respect to initial rates on an abandoned field and a conifer plantation. When tested against measured infiltration rates in an undisturbed oak-hickory woods the model proved to be inadequate.

(82) Sartz, Richard S. 1962. Field transport for the neutron soil-moisture meter. J. Soil. Water Conserv. 17:27.

A three-wheeled buggy for transporting a Nuclear-Chicago neutron-scattering soil-moisture meter is described and illustrated. It is made from the front half of a girl's bicycle frame, a rear axle with heavy-duty bicycle tires, and a plywood carriage. It can be used over rough terrain. Cost was $64.

(83) Sartz, Richard S. 1967. A test of three indirect methods of measuring depth of frost. Soil Sci. 104(4):273-278.

A modified frost penetrometer, which was found to be fast and accurate, was used as a check on indirect methods of measuring depth of concrete frost penetration. Resistance block determinations agreed well with the penetrometer measurements. The Soiltest frostmeter was found to be unreliable as a scientific instrument.

(84) Sartz, Richard S. 1969. Interpreting neutron probe readings in frozen soil. U.S. Dep. Agric. For. Serv., Res. Note NC-77, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Temperature was not important, but the effect of vertical resolution is particularly important in frozen soil because of water and ice buildup on and near the ground surface. The possibility of both downward and upward movement of water complicates the interpretation of neutron probe readings in frozen soil.

(85) Sartz, Richard S., and Willie R. Curtis. 1961. Field calibration of a neutron-scattering soil moisture meter. U.S. Dep. Agric. For. Serv., Stn. Pap. 91, 15 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

A method of calibrating the Nuclear-Chicago neutron-scattering soil-moisture depth probe by gravimetric sampling is explained. Soil moisture contents as determined from the manufacturer's calibration curve were found to be too high at low moisture levels and too low at high moisture levels. Correction factors for shallow readings are given for the particular instrument used.

(86) Sartz, Richard S., and Willie R. Curtis. 1967. Simple sediment sampler for flumes. Agric. Eng. 48(4):224.

A method of automatically collecting suspended sediment samples from flumes is described and illustrated.

Publications—Miscellaneous

(87) Dils, Robert E. 1957. Watershed management research needs in the forests of the Lake

States. Michigan State Univ. Agric. Exp. Stn. Spec. Bull. 416, 35 p.

Provides a survey of watershed management research needs in the northern forest area and the Driftless Area of the Lake States. Describes the water resources and requirements and the problems in watershed management. Background information includes climate, topography and geology, soils, and land use.

(88) Sartz, Richard S. 1962. The Coulee Experimental Forest—A new field laboratory for southwestern Wisconsin. Wisconsin Acad. Review 9(1):1-5.

A popular-style article on research on the Forest and how the Forest came into being.

(89) Sartz, Richard S. 1977. Carlos G. Bates, maverick Forest Service Scientist. J. For. Hist. 21(1):31-39.

Recounts the working life of C.G. Bates, from the famous Wagon Wheel Gap effect-of-forest-on-streamflow study to the Great Plains shelterbelts, his study of floods and erosion in the Driftless Area, and his taking on the dam-builders in the Mississippi River's Flood Control Controversy.

(90) Weitzman, Sidney. 1957. Needed—a forest research program for southwest Wisconsin. Wisconsin Conserv. Bull. 22(3):28-33.

Describes the condition of the forests in southwest Wisconsin with respect to both timber production and watershed protection. Discusses the problems and conflicts that brought about existing conditions. Outlines the research program needed to solve current problems.

LIST OF PERSONNEL

Full-time personnel associated with the research during the periods reported here are listed below, along with their working titles and years of tenure.

Station Directors

Raphael Zon	1928-44
Elwood L. Demmon	1944-51
Murlyn B. Dickerman	1951-63
David B. King	1963-72
John H. Ohman	1972-75

Director's Staff

Carlos. G. Bates, Silviculturist	1928-49
Sidney Weitzman, Division Chief	1957-67
Robert W. Merz, Assistant Director	1967-73
James Morgan, Assistant Director	1973
Arne K. Kemp, Assistant Director	1974-75

Project Staff

John Macon	1929-30
Joseph H. Stoeckeler, Forester	1930-33
Harold F. Scholz, Forester	1933-40
Robert G. Neu, Statistical Clerk	1939-40

Robert G. Nue, Statistical Clerk	1939-40

Joseph H. Stoeckeler, Soil Scientist	1958-63
Richard S. Sartz, Forester-Project Leader	1958-75
Janice M. Johnson, Secretary	1958-66
Willie R. Curtis, Forester	1959-66
David N. Tolsted, Forestry Technician	1962-75
Greta H. Lockhart, Administrative Clerk	1967-75
Boyd A. Hutchison, Forester	1967
Alfred Ray Harris, Soil Physicist	1968-75
M. Dean Knighton, Ecologist	1968-75

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Sartz, Richard S.

1978. Thirty years of soil and water research by the Forest Service in Wisconsin's Driftless Area—a history and annotated bibliography. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. NC-44, 18 p. North Cent. For Exp. Stn., St. Paul, Minnesota.

The history of forest watershed management research in the upper Mississippi Valley's unglaciated region, from its beginning in 1928 to its end in 1975, is narrated along with an annotated bibliography of the research accomplishments.

OXFORD: (048.1)116:116.6:114.12. KEY WORDS: Infiltration, hydrology, erosion, streamflow.

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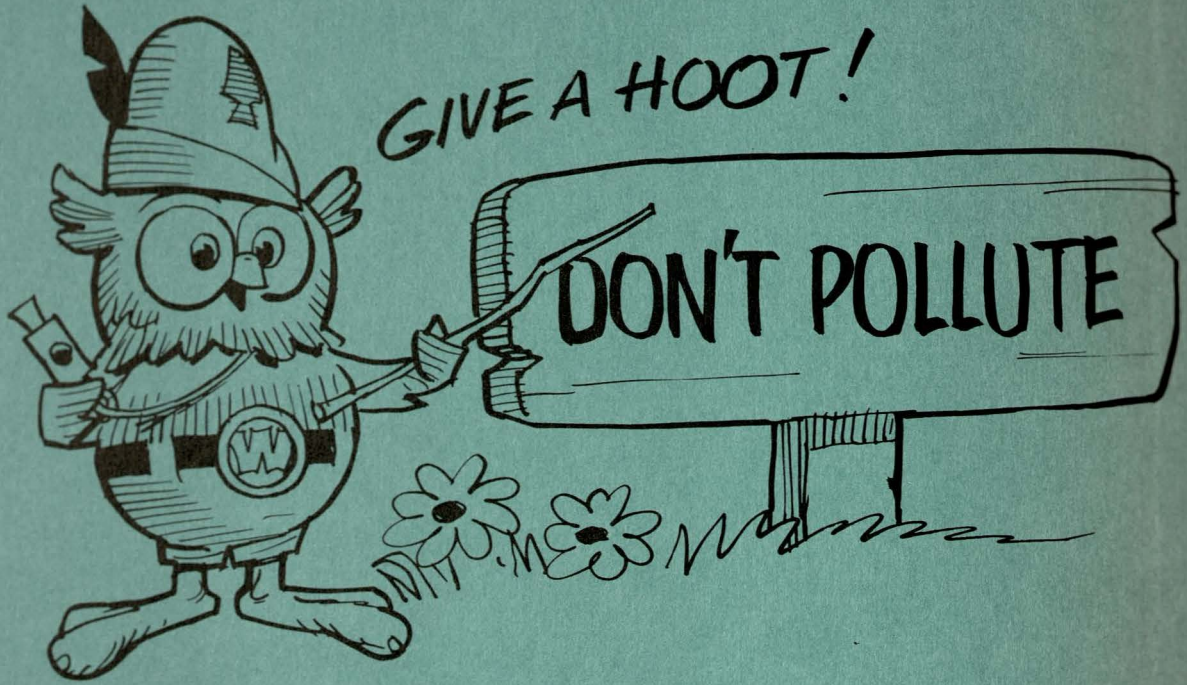
The history of forest watershed management research in the upper Mississippi Valley's unglaciated region, from its beginning in 1928 to its end in 1975, is narrated along with an annotated bibliography of the research accomplishments.

OXFORD: (048.1)116:116.6:114.12. KEY WORDS: Infiltration, hydrology, erosion, streamflow.



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